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MIL-DTL-5886G Ballistic Fragmentation Qualification of the Carleton Life Support Systems Oxygen Cylinder, Part Number 3270081-0201

by Brian G. Smith

ARL-TR-3759 **March 2006**

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14. ABSTRACT

This report documents the MIL-DTL-5886G ballistic fragmentation test of the Carleton Life Support Systems, Inc., oxygen cylinder, manufacturer's part number 3270081-0201. The U.S. Army Research Laboratory (ARL) performed these test procedures on three cylinders at ARL's Air Base Experimental Facility 7, Aberdeen Proving Ground, Maryland. ARL concludes that the oxygen cylinders meet the MIL-DTL-5886G fragmentation resistance requirement. This conclusion is based on the three test events performed on three separate oxygen cylinders: serial numbers 000002155, 000002156, and 000002158. Each test event met the required test configuration parameters, and in all cases, the oxygen cylinder remained as one piece with no evidence of fragmentation.

15. SUBJECT TERMS
ballistic; fragmentation; MIL-DTL-5886; oxygen bottle; oxygen tank; test

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1. Introduction

MIL-DTL-5886G (*1*) provides detailed design and construction specifications for low pressure, nonshatterable, aircraft oxygen cylinders. Included in this specification is a ballistic fragmentation requirement with defined test procedures. The U.S. Army Research Laboratory (ARL) performed these test procedures on three Carleton Life Support Systems, Inc., tanks, manufacturer's part number 3270081-0201, and the results are presented in this report.

2. Oxygen Cylinder's Description

The oxygen cylinder's volume is 750 in^3 and is rated for 350 psig operating pressure (see figure 1). The tank measures 18 inches in length and is 8.125 inches in diameter. One end of the tank is fitted with an open female oxygen pipe thread fitting. The tank is constructed from corrosion-resistant steel with an average measured wall thickness of 0.088 inch.

Figure 1. Oxygen cylinder, part number 3270081-0201.

3. Ballistic Projectile Description

MIL-DTL-5886G requires the ballistic projectile to be the U.S. Army M2 .50 caliber, armor-piercing (AP) ammunition (see figure 2). The AP M2 is a machine gun cartridge intended to be used against lightly armored or unarmored targets, concrete shelters, and similar bullet-resistant

targets (*2*). The projectile measures 2.3 inches in length and has a muzzle velocity of 2,810 feet per sec (fps). MIL-DTL-5886G further defines the projectile as being tumbled at the impact point with a minimum velocity of 2600 fps. The specification requires the entrance hole to measure at least 1.5 inches by 0.5 inch. Therefore, the M2 projectile should impact almost broadside to the oxygen cylinder to achieve the necessary entrance hole size.

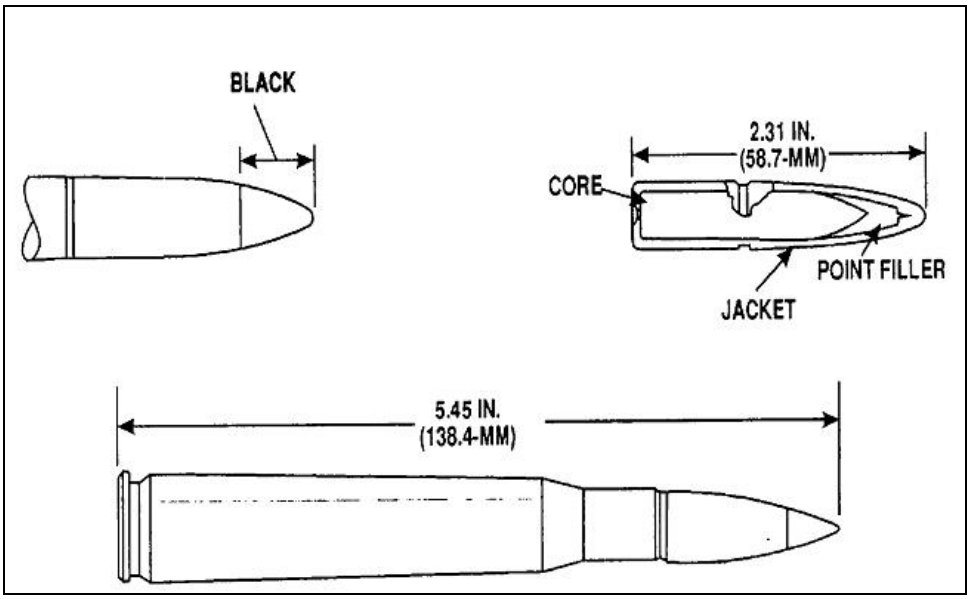

Figure 2. M2 .50 caliber armor-piercing projectile.

4. Projectile Shotlines

MIL-DTL-5886G specifically defines three shotlines:

1. With the longitudinal axis of the cylinder normal to line of fire,
2. With the longitudinal axis of the cylinder 45 degrees from normal toward the gun position,
3. With the longitudinal axis of the cylinder parallel to the line of fire with inlet port face away from the gun position.

These shotlines are depicted in figure 3 for clarity.

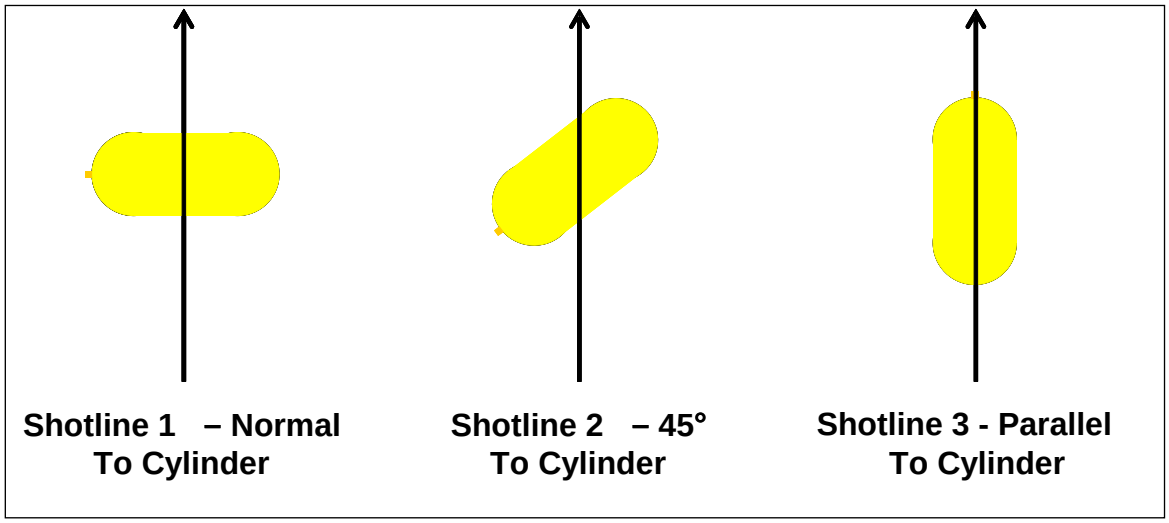

Figure 3. MIL-DTL-5886G shotlines.

5. Instrumentation

The projectile's impact velocity was recorded with a Weibel W-680 radar projectile velocity measurement (PVM) system. The Weibel W-680 radar PVM consists of a tripod-mounted radar head, an optical trigger, and a processing unit. The radar head is mounted adjacent to the gun barrel, aimed at the projectile's intended path. An optical sensor activated by the muzzle flash triggers the radar system. The projectile's velocity is recorded throughout its visible path and recorded digitally by the PVM's processing unit.

High speed digital video was used to capture the projectile's orientation upon impact. A Phantom[1] VII camera, operating at 15,000 frames per second was focused on the impact location. Artificial lighting was used to improve the camera's performance. Normal speed video captured the entire test event and still photography captured pre-test and post-test conditions of the test item.

6. Test Conditions

The MIL-DTL-5886G testing was completed at ARL's Air Base Experimental Facility 7, Aberdeen Proving Ground, Maryland. ARL used a modified .50 caliber, standard twist, Mann gun barrel (rifled) mounted on a Frankfort rest. The modified gun barrel induces a tumbling

[1]Phantom is a registered trademark of Vision Research, Inc.

action to the projectile as it is fired from the barrel. This technique produces highly repeatable and accurate tumbling results. Before the oxygen cylinders were tested, yaw cards were used to establish the correct stand-off distance to achieve a broadside impact of the projectile. The projected impact velocity was also confirmed during these ballistic firings.

The oxygen cylinders were individually placed on a small table-top test stand. As defined in the testing requirements, the cylinders were supported but not constrained. Small wooden wedges were used to hold the oxygen cylinders in position before testing, yet did not prevent them from moving after the ballistic impact.

7. Test Results

7.1 Shotline No. 1

The oxygen cylinder was aligned normal with the projectile's trajectory, as depicted in figure 3. The specific tank tested was identified as serial number 000002158. The tank was pressurized with medical grade oxygen at its operational pressure, 350 psig. The ballistic projectile impacted broadside to the cylinder (figure 4) traveling at 2610 fps. The entrance hole measured 0.8125 inch by 2 inches (figure 5), which met the MIL-DTL-5886G requirements. The projectile's exit created an irregularly shaped hole with general dimensions of 3.5 inches by 3.5 inches (figure 6). The oxygen cylinder remained as one piece with no evidence of shattering or fragmentation (figure 7).

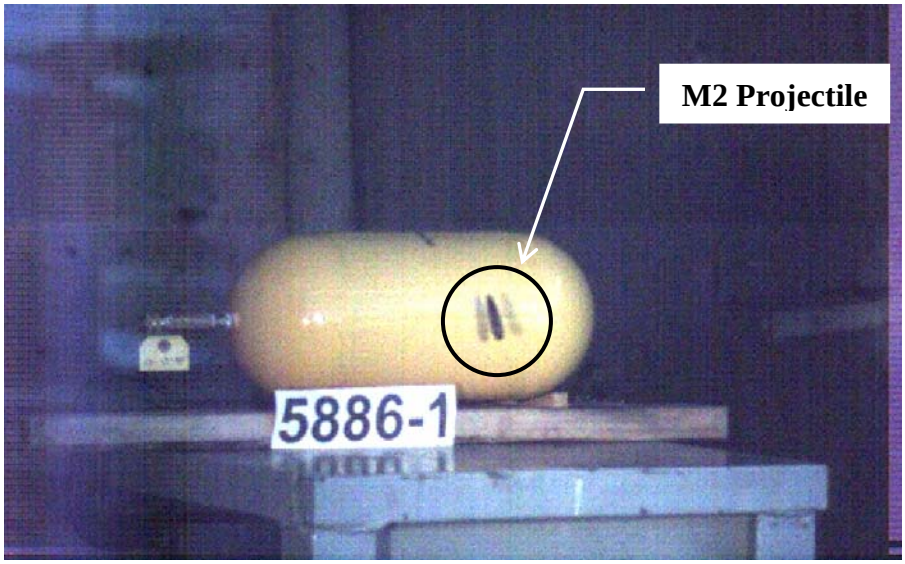

Figure 4. Projectile impact for shotline 1 test.

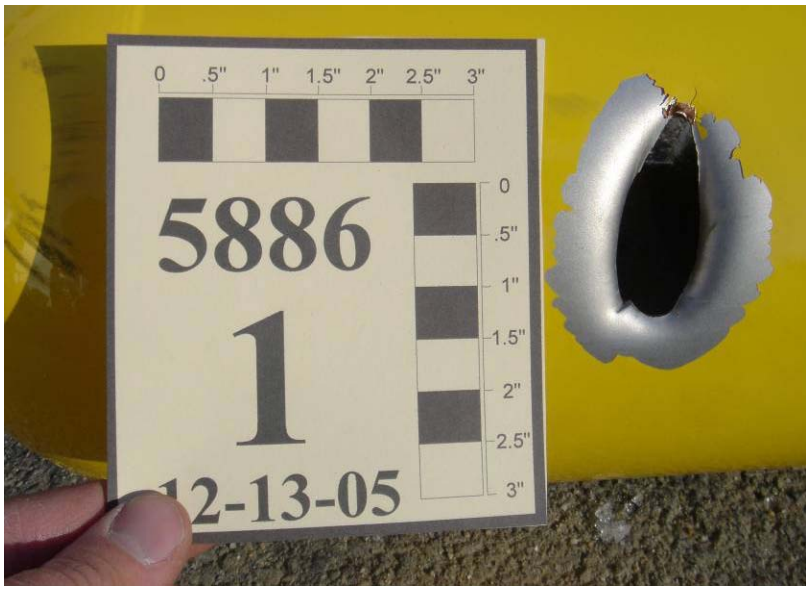

Figure 5. Entrance hole for shotline 1 test.

Figure 6. Exit hole for shotline 1 test.

Figure 7. Overall condition of the oxygen cylinder for shotline 1 test.

7.2 Shotline No. 2

The oxygen cylinder was aligned at a 45-degree angle with the projectile's trajectory as depicted in figure 3. The specific tank tested was identified as serial number 000002155. The tank was pressurized with medical grade oxygen at its operational pressure, 350 psig. The ballistic projectile impacted broadside to the cylinder (figure 45) traveling at an estimated 2616 fps[2]. The entrance hole measured 1 inch by 2.375 inches (figure 9), which met the MIL-DTL-5886G requirements. The projectile's exit created an irregular, triangular hole with general dimensions of 7 inches by 5.5 inches (figure 10). The oxygen cylinder remained as one piece with no evidence of shattering or fragmentation (figure 11).

Figure 8. Projectile impact for shotline 2 test.

[2]The instrumentation failed to record a projectile velocity. The average velocity of five set-up tests and the two other oxygen cylinder tests was 2616 fps.

Figure 9. Entrance hole for shotline 2 test.

Figure 10. Exit hole for shotline 2 test.

Figure 11. Overall condition of oxygen cylinder for shotline 2 test.

7.3 Shotline No. 3

The oxygen cylinder was aligned parallel to the projectile's trajectory as depicted in figure 3. The specific tank tested was identified as serial number 000002156. The tank was pressurized with medical grade oxygen at its operational pressure, 350 psig. The ballistic projectile impacted broadside to the cylinder (figure 12) traveling at 2599 fps. The entrance hole measured 0.9375 inch by 2.125 inches (figure 13), which met the MIL-DTL-5886G requirements. The projectile's exit created an irregular, rectangular hole measuring 1.125 inches by 2.5 inches (figure 14). The oxygen cylinder remained as one piece with no evidence of shattering or fragmentation (figure 15).

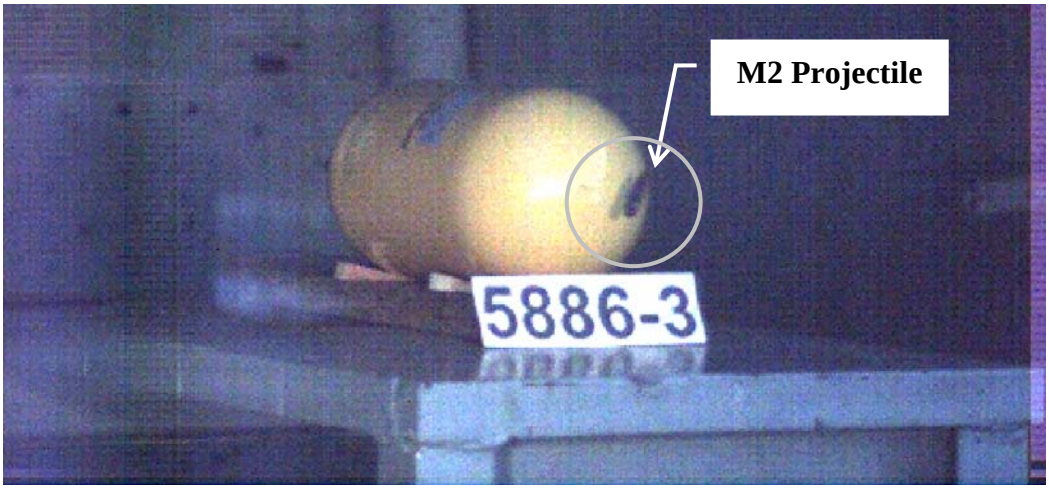

Figure 12. Projectile impact for shotline 3 test.

Figure 13. Entrance hole for shotline 3 test.

Figure 14. Exit hole for shotline 3 test.

Figure 15. Overall condition of oxygen cylinder for shotline 3 test.

8. Conclusions

ARL concludes that the Carleton Life Support Systems, Inc., oxygen cylinder, manufacturer part number 3270081-0201, meets the MIL-DTL-5886G fragmentation resistance requirement. This conclusion is based on the three test events performed on three separate oxygen cylinders (serial numbers 000002155, 000002156, and 000002158). Each test event met the required test configuration parameters and in all cases, the oxygen cylinder remained as one piece with no evidence of fragmentation.

9. References

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2. Headquarters, Department of the Army. *Army Ammunition Data Sheets - Small Caliber Ammunition*; TM 43-0001-27; Washington DC, April 1994.

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